REMARKS

Examiner Guharay is thanked for a telephone interview she conducted with the undersigned Agent on October 18, 2007. During the telephone interview the Hunt reference was discussed and an amendment to claim 1 was considered.

Amendments:

Claim 1 has been amended. No new matter is added by this amendment.

The Applicants respectfully request reconsideration of the claims.

The Invention As-Claimed:

As recited in amended claim 1, the invention provides a carbon nanotube device. The device has a substrate including an aperture extending from a front surface to a back surface of the substrate. The aperture is open only at the substrate front surface and back surface. At least one pair of electrically conducting contact pads is disposed on a selected one of the front and back substrate surfaces. The conducting contact pads in a given pair of pads are separated from each other by the aperture in the substrate surface on which they are together disposed.

A carbon nanotube catalyst region is disposed on top of each of the contact pads on the selected substrate surface, in alignment with an edge of the aperture. The catalyst regions are exposed at the selected substrate surface. At least one carbon nanotube extends across the aperture and is accessible through the aperture from both the front surface and the back surface of the substrate. Each end of the carbon nanotube contacts an exposed catalyst region on a contact pad at the selected substrate surface.

Claim Rejections:

Claims 1-2, 6, 8-9, 11, 15, 32, and 34-40 were rejected under 35 U.S.C. §102(e) as being anticipated by Hunt et al., U.S. patent application publication US 2002/0167374 (hereinafter "Hunt").

The Examiner suggested that Hunt discloses and illustrates in Hunt Fig. 1 a carbon nanotube device having a substrate that is provided by Hunt as supports 14, 16, with an aperture 22 extending from a front surface to a back surface. The Examiner suggested that Hunt teaches a pair of conductive pads 18, 20, disposed on a front surface, with the pads in a given pair being separated form each other by the aperture. The Examiner suggested that Hunt teaches a carbon nanotube catalyst region 17 disposed on top of a contact pad 18 in alignment with an edge of an aperture, with a carbon nanotube 24 extending across the aperture and accessible through the aperture from both sides of the substrate, contacting an exposed catalyst region on a contact pad at the selected substrate surface.

Amended claim 1 requires that there be provided a substrate including an aperture extending from a front surface to a back surface of the substrate. The aperture is required to be open only at the front surface and back surface of the substrate. The Examiner indicated that for the purpose of claim examination, the gapped Hunt support structure 14, 16, is to be considered a substrate. The supports 14, 16, are provided across a gap on a substrate surface 12 (Hunt ¶41, lines 3-4 and Hunt Fig. 1) but in the Examiner's analysis, the gapped supports are to be regarded as a substrate.

With the Hunt support structure 14, 16, regarded as a substrate, this substrate includes a gap 22 (Hunt ¶41, line 6). The gap 22 is open at the top of the supports 14, 16, and at the sides of the supports. This is shown clearly in Hunt Fig. 1, where an RF input 28 (Hunt ¶41, line 16) extends through the gap and beyond the edges of the supports 14, 16, out through the gap between the supports 14, 16. The supports 14, 16, must be open at

the sides so that this RF input 28 can be connected to circuitry outside of the device region. The very term "gap" used by Hunt indicates a separation between the supports 14, 16, that is open at the sides of the supports.

But amended claim 1 requires that there be provided in a substrate an aperture, not a open-edge gap such as Hunt's, and requires that the aperture be open only at the front surface and back surface of the substrate. If Hunt's gapped support structure 14, 16, is to be considered a substrate, then this structure fails to meet the requirements of the claims because Hunt's gapped support structure is entirely open at the edges, rather than only at the front surface and back surface as required by the claims.

As explained previously, the invention provides particular advantages with the requirement, as recited in amended claim 1, of a substrate through which an aperture completely extends to be open between two surfaces for separating contact pads on one of the surfaces. As explained at ¶¶26-27 of the instant Specification, with a substrate including such an aperture, a nanotube can be synthesized to form a bridge across the aperture to make contact between two electrodes that are provided on a surface of the substrate. As explained at ¶28, gas or liquid can then be directed through the substrate itself for nanotube-based sensing or other applications. This enables a compact arrangement in which nanotube synthesis is incorporated with planar microfabrication to produce planar, substrate-based nanotube devices and systems, and allows for use of a microfabrication substrate directly in a nano-electromechanical application.

Claim 1 further requires that there be disposed a carbon nanotube catalyst region on top of each in at least one pair of contact pads disposed on a selected front and back surface of the substrate. In the Hunt configuration, as shown in Hunt Fig. 1,a catalyst spot (17 in Hunt Fig. 1) is provided on only one electrode 18, with the second electrode 20 not provided with a catalyst spot. Correspondingly, in Hunt Figs. 5A-5D, it is shown that a Nb catalyst is patterned only on the left side of the gap. In the upper figure of Hunt Fig. 5D

this is clearly shown with patterned Nb regions on the left of the gap. In the lower figure of Hunt Fig. 5D the un-stippled region is silicon (Si/SOI/Nb starting material ¶59, line 2). Hunt makes this clear in Hunt Fig. 8 where growth of a nanotube 24 from one catalyst region 17 on a patterned surface 21 is described.

The Applicants therefore respectfully submit that Hunt neither teaches nor suggests the carbon nanotube device of claim 1.

Claims 10, 31, 33, and 41 were rejected under 35 U.S.C.§103(a) over Hunt as in claim 1. Claims 3-5 were rejected under 35 U.S.C. §103(a) as being unpatentable over Hunt in view of Brown et al., U.S. No. 6,297,063, (hereinafter "Brown"). Claim 12 was rejected under 35 U.S.C. §103(a) as being unpatentable over Hunt in view of Bradley et al. U.S.2004/0043527 (hereinafter "Bradley").

Claims 2-6, 8-12, 15 and 31-41 all depend from claim 1 and include all of the limitations of claim 1. Thus, for any combination of recited limitations in the dependent claims that are suggested by Hunt, Brown and/or Bradley, Hunt, Brown, and Bradley fail to teach or suggest the limitations of claim 1 as included in all other claims.

For example, claim 2 requires a single-walled carbon nanotube; claim 3 requires a multi-walled carbon nanotube; claim 4 requires a semiconducting carbon nanotube; claim 5 requires a metallic carbon nanotube; claim 6 requires a plurality of carbon nanotubes; and claim 8 requires a semiconducting substrate. Claim 15 requires a plurality of pairs of contact pads. Claim 31 requires a 2 nm-thick catalyst region; 32 requires each catalyst region to cover a portion of a contact pad, and claim 33 requires each catalyst region to cover substantially an entire contact pad. Claim 34 requires an edge of the contact pad to be at the aperture periphery; claim 35 requires contact pads to make connection to circuitry; claim 36 requires contact pads to make connection to at least one device. Claim 37 requires a silicon substrate, claim 39 requires Pt or Cr contact pads;

claim 40 requires Fe, Co, or Ni catalyst regions; and claim 41 requires 17×10^{15} atoms/cm^2 catalyst region layer coverage. For any of these specific example limitations suggested by Hunt or Brown, Brown and Hunt fail to teach or suggest a substrate having an aperture through the substrate and open only at the front and back surfaces of the substrate with a carbon nanotube extending across the aperture and connected between catalyst regions that are exposed on the substrate and on top of contact pads on the substrate as required by the claims.

Claim 9 requires that the substrate include a membrane; claim 10 requires that the membrane be a silicon nitride membrane; claim 11 requires that the membrane be a silicon dioxide membrane; and claim 38 requires that the membrane be supported at its edges by a substrate.

The Examiner pointed to Hunt Fig. 5D as showing a SiO_2 layer on a top surface of which is disposed a contact pad and a catalytic region for a nanotube. As explained by the undersigned Agent during the Examiner interview, this Hunt SiO_2 layer is not a membrane. A membrane is a very specific and well-defined term of art in microelectromechanical systems. As explained in the instant application at ¶39 and ¶40, a membrane is "free-standing" and "suspended;" it is like a trampoline or sheet of plastic wrap covering a bowl. The suspended membrane material has no support below it such that the suspended layer is free to deflect vertically.

In the instant application Figs. 4B and 5B illustrate planar views of membranes in accordance with the invention. The region 18 in Figs. 4B and 5B that is dotted is a square suspended membrane region. This region is shown in cross section in Figs. 4A and 4B as not having any substrate material 12 beneath it. The nanotube 10 is disposed across an aperture in the membrane 18.

Claims 9-11 and 38 require that an aperture be provided in the membrane and that the aperture be open only at the front and back surfaces of the membrane. The gap arrangement of Hunt's support structure does not meet this requirement and provides no self-supporting region like the membrane required by these claims.

Claim 12 requires that the substrate be aligned between a source of electrons and an electron detector for nanometer-scale transmission electron microscopy of the carbon nanotube.

Claim 12 was rejected under 35 U.S.C. §103(a) as being obvious over Hunt in view of Bradley et al., U.S. Publication No. 20040043527 (hereinafter "Bradley"). Referring to Bradley ¶¶55-56, the Examiner suggested that Bradley teaches a support structure holding a nanotube and aligned with a source of electrons and an electron detector for transmission electron microscopy.

The Applicants respectfully submit that this is not the case. In Bradley Fig. 2, referred to at ¶¶55-56, there is shown a substrate 230. A nanotube 210 is shown laying on the surface of the substrate 230. A voltage supply 240 applies a voltage to the substrate 230. A second supply 250 provides the same voltage to the nanotube. A meter 260 measures the difference in current through the nanotube that results from exposure of the nanotube to an environment of interest. (¶¶55-56).

This electrical circuit and current measuring technique is not transmission electron microscopy as required by claim 12. Microscopy, by definition, involves forming a micro-scale image. In transmission electron microscopy (TEM), electrons are directed through a structure of interest and after passing through the structure, are collected at a detector. TEM is not an electrical circuit such as that shown by Bradley.

As explained in the instant specification at ¶27, it is generally recognized by those skilled in the art that nm-scale TEM resolution is required to enable sufficient precision in nanotube analysis. Such cannot be achieved if the transmitting electrons must traverse a substrate. It is discovered in accordance with the invention that the substrate aperture provided by the invention enables alignment of the substrate between a source of electrons and an electron detector so that TEM can be carried out on a nanotube in place across an aperture in a substrate without the need to remove the nanotube from the substrate. No destruction of a nanotube under investigation is required to achieve nanometer-scale TEM resolution.

Neither Bradley nor Hunt, nor any combination of the two, teach or even hint at transmission electron microscopy, let alone nanometer-scale transmission electron microscopy and how such could be carried out with a nanotube in place across an aperture on a substrate as required by the claim.

With this discussion the Applicants respectfully submit that the claims are in condition for allowance, which action is requested. If the Examiner has any questions or would like to discuss the amendments, she is encouraged to telephone the undersigned Agent at the number given below.

An Information Disclosure Statement accompanies this response.

Respectfully Submitted

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